

CHEMICAL CONTROL AND INTERREGULATION

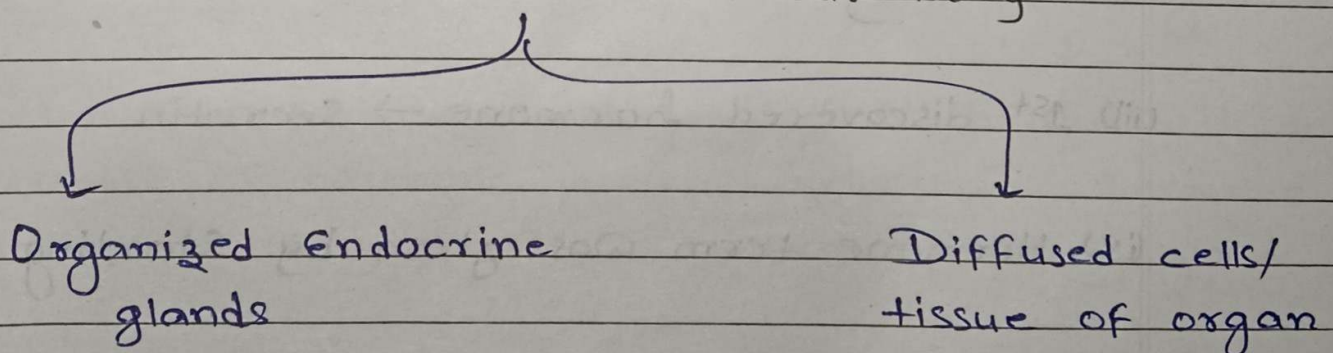
* Introduction

- In our body, neural system and endocrine system jointly coordinate and regulate functions of our body.
- Endocrine glands are ductless gland, which - produce hormone directly into blood

* Hormone

- Classical definition: Hormones are chemical produce by endocrine gland directly into the blood, and transported to distantly located target organ.
- New definition: Hormones are non-nutrient chemicals, acting as intercellular messenger, produce in trace amount

* Source of hormone in our body



- Organized endocrine gland includes:-
 - (i) Hypothalamus
 - (ii) pineal
 - (iii) pituitary
 - (iv) Thyroid
 - (v) parathyroid
 - (vi) Thymus
 - (vii) pancreas
 - (viii) Adrenal
 - (ix) Gonads (ovary in female and testes in male)
- Diffused cells/tissues of organ includes:-
 - (i) Heart
 - (ii) Kidney
 - (iii) liver
 - (iv) GIT (Gastro intestinal tract)

note:-

- (i) Lower invertebrates have simple endocrine system with few hormones
- (ii) Vertebrates have complex endocrine system with many hormones
- (iii) 1st discovered hormone → Secretin
- (iv) Hormone term was given by Starling

(v) Master gland in our body → pituitary

(vi) Master of master gland in our body → Hypo-
thalamus

★ Hypothalamus

- location : basal part of thalamus (diencephalon, fore^{brain})
- Hypothalamus is known as master of master gland as it regulate synthesis and secretion of hormone from pituitary gland (master gland)
- Hypothalamus have neurosecretory cells called nuclei
- Nuclei produce hormones (Hypothalamic hormone)
- Hypothalamus hormones are of two types :

Releasing hormone

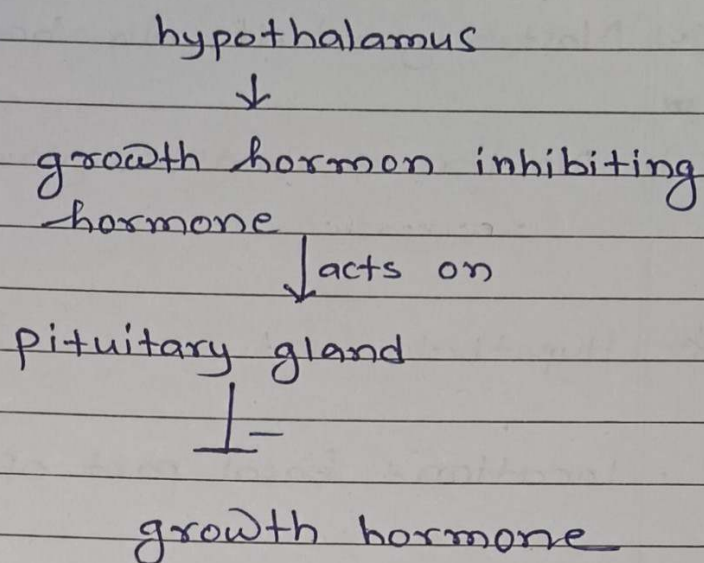
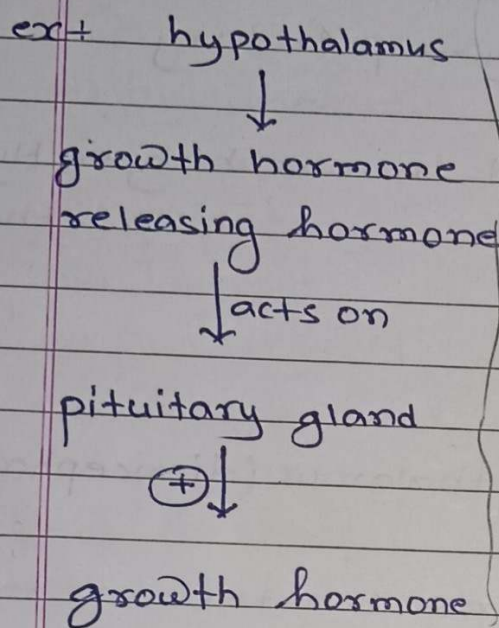


Stimulate synthesis and
release of hormone
from pituitary gland

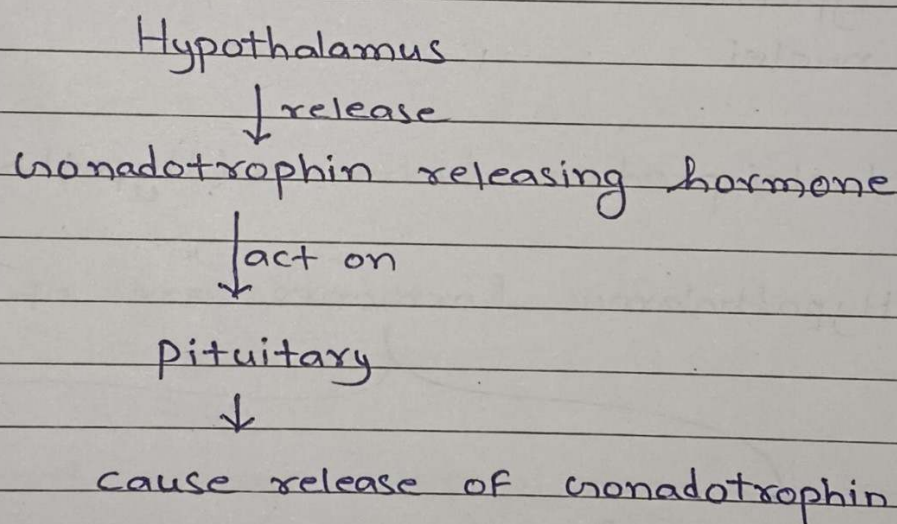
Inhibiting hormone



Inhibit synthesis and
release of hormone
from pituitary gland.



- note:-
 • growth hormone releasing hormone = somatotrophic
 • growth hormone inhibiting hormone = somatostatin

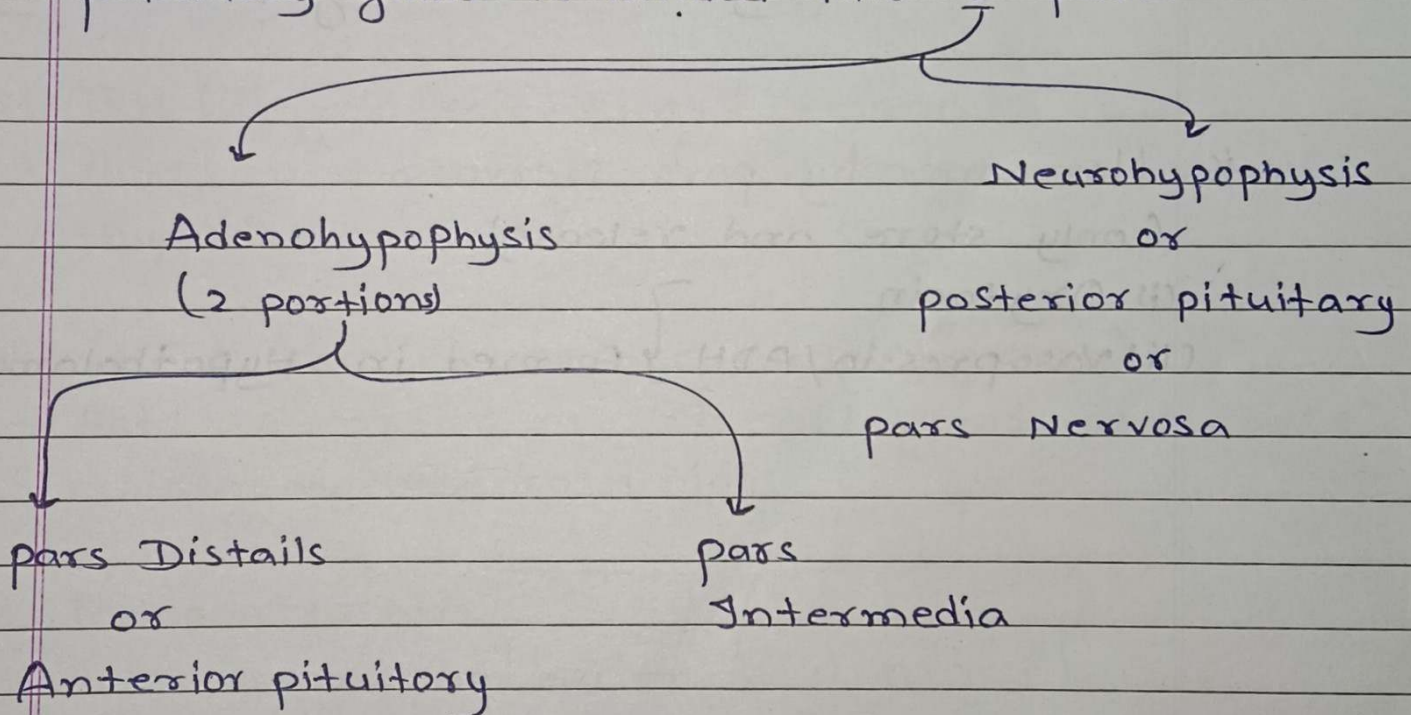


note:-

- There is Hypophyseal portal system b/w hypothalamus and anterior pituitary
- posterior pituitary is under direct neural regulation of hypothalamus.

* Pituitary gland (Master gland)

- location in a cavity called sella turcica (formed by sphenoid bone)
- pea size gland
- Hypothalamus and pituitary is connected by a stalk called Infundibulum.
- Pituitary gland is divided into 2 parts



* Hormones by pars Distalis

- (i) Growth hormone
- (ii) prolactin
- (iii) TSH (Thyroid stimulating hormone)
- (iv) ACTH (Adreno cortico trophic hormone)
- (v) LH (Leutinizing hormone)
- (vi) FSH (follicle stimulating hormone) } gonadotro
- phin

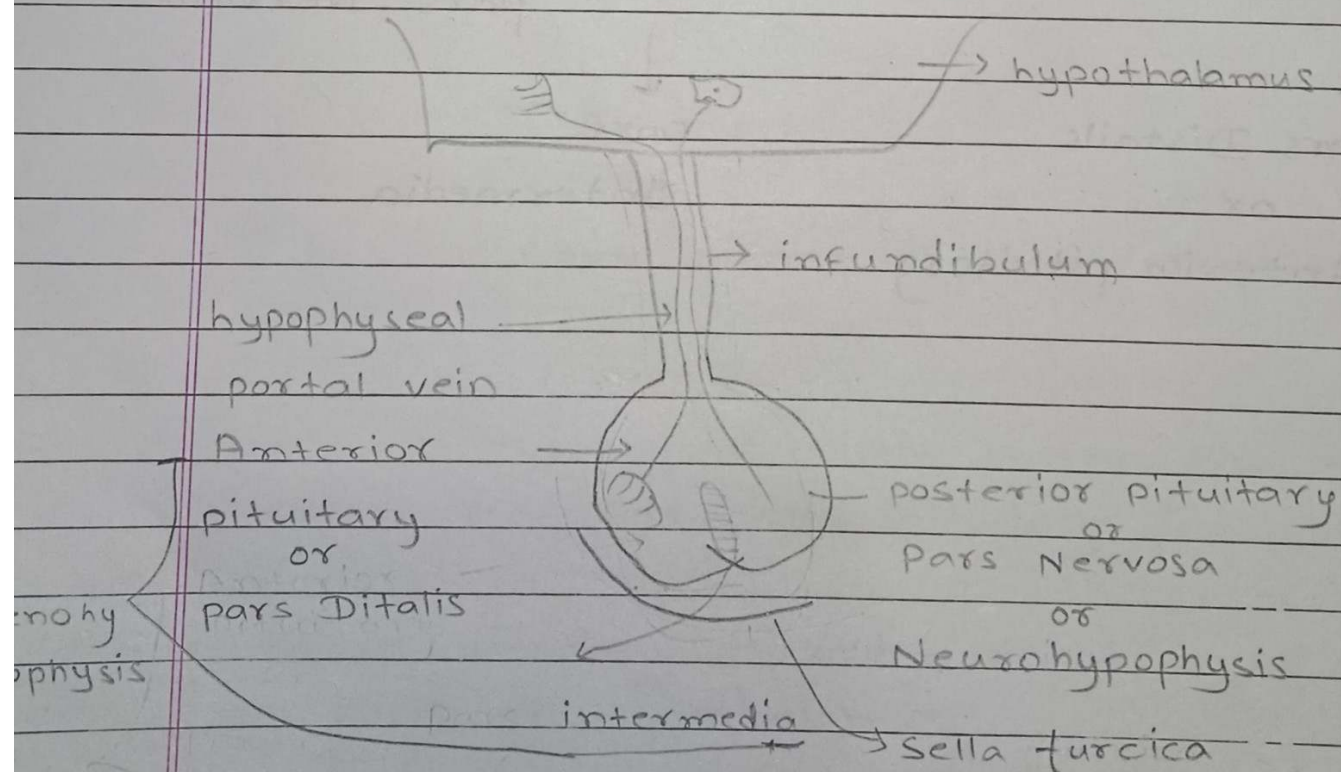
* Hormone by pars intermedia

- (i) MSH (Melanocyte stimulating hormone)

* Hormone by pars Nervosa

(only store and release)

- (i) Oxytocin
- (ii) Vasopressin / ADH } formed in Hypothalamus



note:- In human, pars intermedia is almost merged with pars distalis.

* Function of hormone release from pituitary

(1) Growth hormone

→ Growth of body

(2) prolactin

→ formation of milk

→ Development of mammary gland.

(3) TSH (Thyroid stimulating hormone)

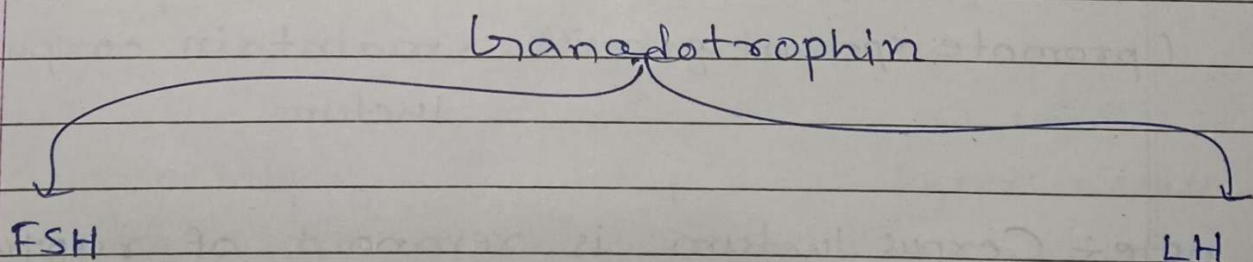
→ Acts on thyroid gland and cause release of thyroid hormone

(4) ACTH (adreno cortico-tropic ^{hormone} gland)

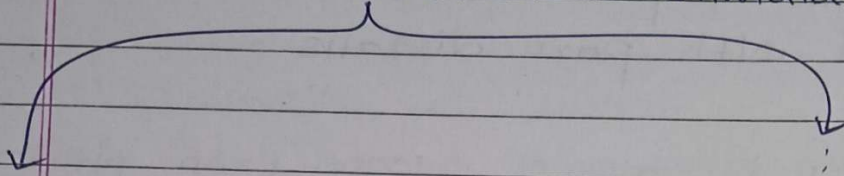
→ Acts on cortex of adrenal gland and cause release of glucocorticoid.

(5) Gonadotrophin

→ Acts on gland (testes and ovary)



FSH (Follicle stimulating hormone)



male

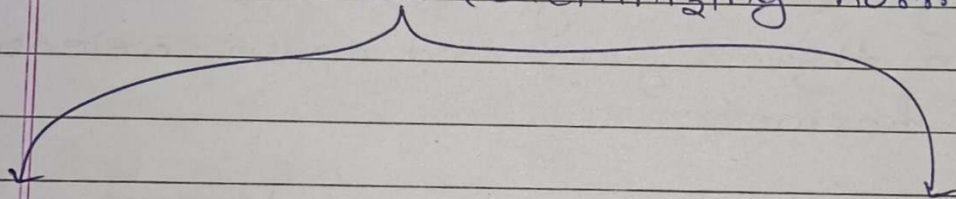
- promote spermatogenesis (sperm formation)

female

- promote growth of ovarian follicle

1st → 2nd → 3rd → graffian follicle follicle follicle follicle

LH (Luteinizing hormone)



male

LH
↓

leyding cell

↓ release

Testosterone

(promote spermatogenesis)

female

↓

LH cause :

- rupture of graffian follicle
- release of ova (ovulation)
- forms corpus luetum
- maintain corpus luetum

note : Corpus luetum is remnant of ruptured graffian follicle

(6) MSH (melanocyte stimulating hormone)

→ Acts on melanocyte (melanin containing cell) and cause darkening (pigmentation) of skin.

(7) Oxytocin

→ Cause contraction of smooth muscle

→ Also known as Birth hormone because it cause contraction of uterine muscle and helps in child birth.

→ Also known as milk let down hormone because it cause ejection of milk from mammary gland.

(8) Vasopression / ADH (anti-diuretic hormone)

→ It prevent diuresis

→ Acts on renal tubule and cause reabsorption of H_2O

→ Acts as vasoconstrictor.

★ Disorders

(1) Growth hormone

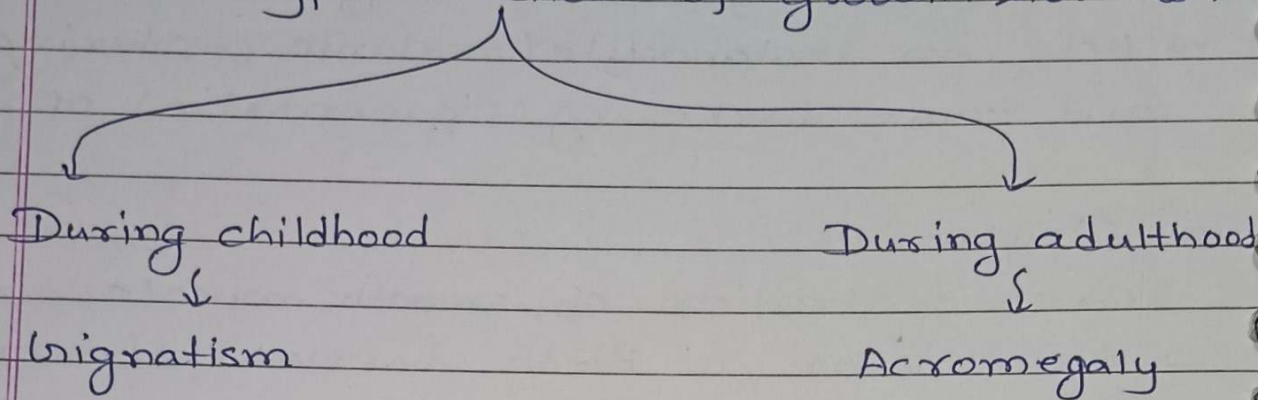
↓
hyposecretion

↓
Dwarfism

(stunted growth)

↓
hypersecretion of growth hormone

hypersecretion of growth hormone



- Acromegaly

- ~~severe~~ severe disfigurement in face
- Difficult to diagnose
- premature death

(2) Diabetes insipidus

- lack of ADH cause diuresis
- loss of water through urine increases
- Dehydration

* ~~Pinn~~ Pineal gland

- Dorsal side of forebrain (in epithalamus)
- Also known as epiphysis cerebri
- Secretes melatonin:
- function of melatonin:
 - (a) maintain 24-hour cycle (circadian cycle)
 - (b) Sleep wake cycle
 - (c) Metabolism
 - (d) Body temperature

- (e) pigmentation (cause lightening of skin)
- (f) Defense capability
- (g) Menstrual cycle

note: Antagonistic relation

↳ opposite work/action

eg: Melatonin MSH
 cause ↓ lightening ↓ cause darkening of skin
 of skin

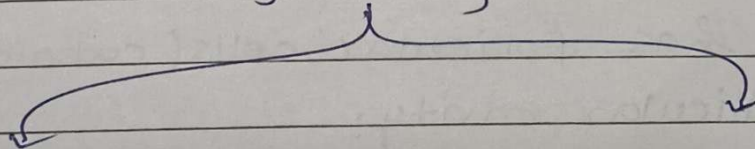
Melatonin and MSH are antagonistic to each other

* Thymus

lobular gland

- location: b/w lungs, behind sternum on ventral side of axilla.
- Secrete thymosin hormone
- Thymus play important role in development of immune system.
- Immunity is the ability of body to fight - against disease causing organism and protect our body.

Immunity



Humoral immunity

Cell-mediated immunity

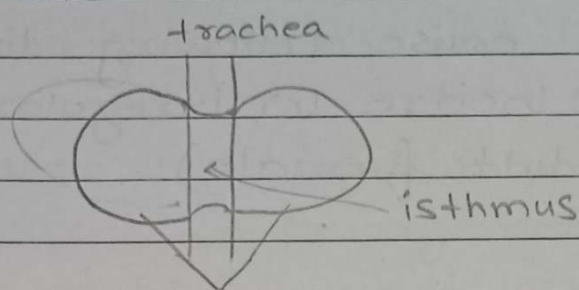
provide

- Humoral immunity
 - provided by B-lymphocyte
 - antibodies are produced
- Cell-mediated immunity
 - provided by T-lymphocyte
- note: With age, size of thymus gland decreases
Old individuals have degenerated thymus gland
↓
low level of thymosin
↓
Weak immune system

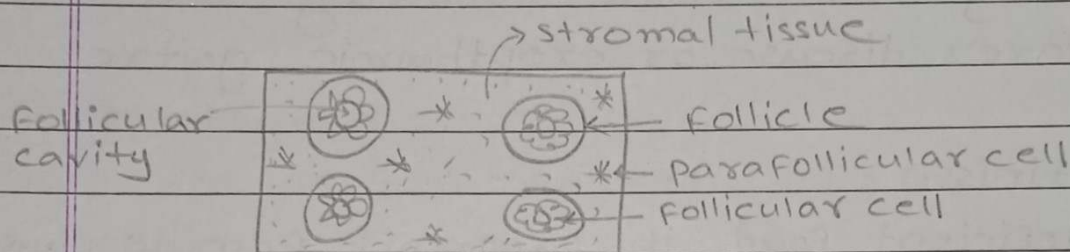
* Thyroid gland

- Bilobed gland (2 lobes)
- Each lobe is located on either side of trachea
- Both lobes are connected to each other by a thin flap of connective tissue called isthmus (non-glandular)
- largest endocrine gland
- Thyroid gland is composed of: Follicle and stromal tissue
- follicle has follicular cells (cuboidal cells) and follicular cavity.
- follicular cells secrete two hormones
 - (i) T_3 → triiodothyronine
 - (ii) T_4 → tetraiodothyronine

- Iodine is essential for production of thyroid hormone



bilobed thyroid gland



T.S of thyroid gland

note: Stromal tissue of thyroid gland has parafollicular cells

- parafollicular cells secrete thyrocalcitonin hormone that regulate Ca^{2+} level in blood

* function of thyroid gland

- regulate BMR (basal metabolic rate)
- stimulate RBC formation (erythropoiesis)
- Metabolism of carbohydrate, protein etc.
- Electrolyte - H_2O balance in body
- Menstrual cycle of female.

* Disorder of thyroid gland

- Hypothyroidism cause following disorder
(a) Cretinism (b) Goitre (c) irregular menstrual cycle (in adult female)

* ~~Hypersecretion~~

- Hyperthyroidism cause following disorder
(a) Grave's disease or exophthalmic goitre

* Cretinism

I_2 deficient food in pregnant female cause hypothyroidism which effects the growth of developing baby by stunted growth, abnormal skin, low IQ, deaf mutism, and mental retardation.

* Goitre

- Due to I_2 deficiency in diet
- Enlargement of thyroid gland
- Effect of hypothyroidism

* Irregular menstrual cycle

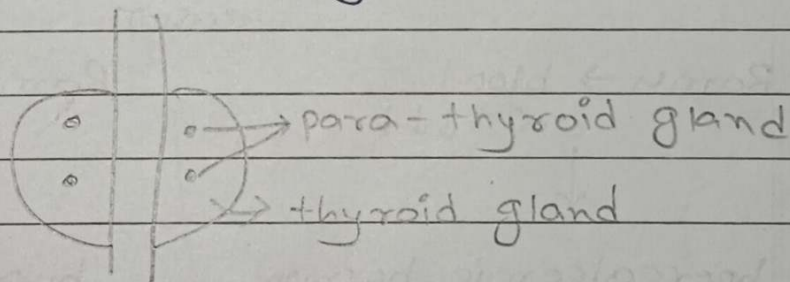
- In adult female, hypothyroidism cause irregular menstrual cycle

* Exophthalmic Goitre / Grave's disorder

- Auto immune disorder
- Due to cancer or nodule formation in thyroid gland.
- follicular cells secrete excess thyroid hormone.
- Characteristics ÷ enlargement of thyroid gland, increased BMR, weight loss, and protrusion of eye balls.

* Parathyroid

- 2 pairs or 4 in number
- located on dorsal side of thyroid gland
- One pair parathyroid gland in each lobe of thyroid gland.
- Parathyroid gland secrete parathyroid hormone.
- Parathyroid hormone regulate Ca^{2+} level in blood



Dorsal view of thyroid gland

- Both thyrocalcitonin hormone (by parafollicular cells of thyroid gland) and parathyroid hormone jointly regulate Ca^{2+} level in blood

- Thyroidal calcitonin

- Hyposecretion of Ca^{2+} (hypocalcemic)
- deposition of Ca^{2+} of bone
- decrease absorption of Ca^{2+} from digestive food.
- decrease reabsorption of Ca^{2+} from renal tubule (nephron)

- Parathyroid hormone

- Hyper secretion of Ca^{2+} (hypercalcemic)
- resorption/demineralization of Ca^{2+} from bone
- increase absorption of Ca^{2+} from digested food
- increase reabsorption of Ca^{2+} from renal tubule (nephron)

Case I.

Ramu → blood
 $Ca^{2+} \downarrow \downarrow \downarrow$
↓

hypercalcemic hormone



→ normal Ca^{2+} level in blood

Case II.

Ram → blood
 $Ca^{2+} \uparrow \uparrow \uparrow$
↓

hypocalcemic hormone



→ normal Ca^{2+} level in blood

* Adrenal gland

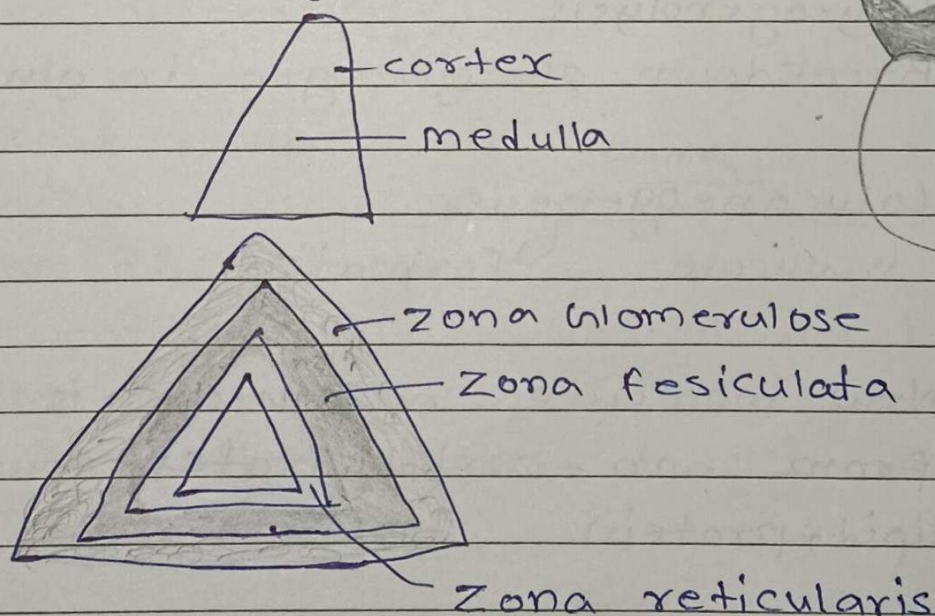
- 1 pair or 2 in number
- present anterior part of each kidney or above the kidney.
- Adrenal gland has two types of tissue

(1) Cortex

- Outer or periphery portion
- consist of three layer
 - (i) Zona glomerulosa (outer)
 - (ii) Zona fasciculata (middle)
 - (iii) Zona Reticularis (inner)
- cortex secrete corticoid hormone (steroid nature)

(2) Medulla

- inner or central portion
- Medulla secrete emergency hormone or Catecholamine (amine nature)
- Secreted during emergency condition



- Emergency condition = 3F (fear, fight, flight)
So, catecholamine is also known as hormone of fight or flight
- Emergency hormone causes:-
 - (i) increase alertness
 - (ii) Sweating
 - (iii) piloerection (raising of hairs)
 - (iv) Increase heart beat rate
 - (v) Increase respiration
 - (vi) Increase strength of contraction of heart
 - (vii) pupil dilation
 - (viii) Increase level of glucose in blood

By glycogenolysis

By gluconeogenesis

- Glycogenolysis
Breakdown of glycogen in glucose

- Gluconeogenesis
glucose ^{new} formation

→ New molecule of glucose is formed from non-carbohydrates source like lipid & protein.

- lipolysis $\rightarrow$ Breakdown of lipid
- proteolysis $\rightarrow$ Breakdown of protein

- Hormone secreted by adrenal cortex

(1) Zona glomerulosa

- $\rightarrow$ Secrete mineralocorticoid (e.g. aldosterone)
- $\rightarrow$ mineralocorticoid regulate balance of water and electrolyte in body.
- function of aldosterone
 - (a) increase reabsorption of H_2O and Na^+ from renal tubule
 - (b) increase excretion of K^+ and phosphate

(2) Zona fasciculata

- Secrete glucocorticoid (e.g. cortisol)
- glucocorticoid regulate metabolism of carbohydrate.
- function of cortisol:
 - (a) involved in inflammatory reaction
 - (b) stress hormone
 - (c) acts as immunosuppressant
 - (d) increase RBC production
 - (e) effect cardiovascular health and kidney function
 - (f) increase level of glucose level in blood.

(3) Zona reticularis

- Secrete sex-corticoid (e.g. androgen)
- Androgen cause growth of axillary hairs, pubic ~~pub~~ pubic hairs, facial hair during puberty

* Disorders related to adrenal ^{hormone} gland

Hyposecretion
of glucocorticoid



Addison's disease

→ acute weakness
and fatigue

hypersecretion

Mineralocorticoid



Conn's disease

Glucocor-
ticoid

moon like face

* Pancreas

~~Heteroglo~~

Heterocrine gland (composite gland)

Exocrine
gland

Endocrine
gland.

- Exocrine portion of pancreas
 - 98-99% of pancreas
 - unit = Acini
 - Secrete pancreatic juice which helps in digestion
- Endocrine portion of pancreas
 - 1-2% of pancreas
 - unit = islet of Langerhans
 - 1-2 million of islet of Langerhans
 - secrete hormone
 - Glucagon (by α cell)
 - Insulin (by β cell)
 - Somatostatin (by δ cell)

* Somatostatin

→ Regulate α and β cells of pancreas.

* Glucagon (act on hepatocyte)

- It increase level of glucose in blood
- It stimulate glycogenolysis, gluconeogenesis and reduce uptake and use of glucose by cells. because of it level of glucose increases in blood

* Insulin

Hypoglycemic hormone

- It decrease level of glucose in blood
- Stimulate glycogenesis (formation of glycogen)
- enhance uptake and use of glucose by cells

- stimulate lipogenesis (formation of lipid)
- level of glucose in blood decrease (~~hyper~~ Hypoglycemic condition)
- Act on hepatocyte (liver cell) and adipocyte (fat storing cell)
- Disorder
Diabetes mellitus
- prolonged hyperglycemic condition due to lack of insulin.
- Glucose is ~~produce~~ excreted along with urine
- formation of harmful ketone bodies.

case-I

person A



Blood glucose decrease (hypoglycemic condition)



To increase blood glucose level hyperglycemic hormone) glucagon is released

person B



Blood glucose increase (hyperglycemic condition)



To decrease blood glucose level hypoglycemic hormone (i.e. insulin) is released

Conclusion

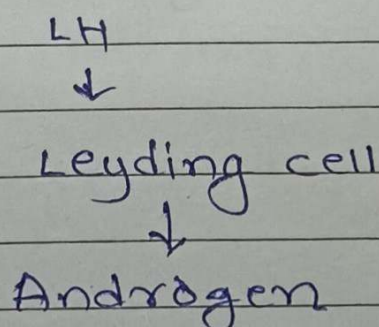
Both glucagon and insulin jointly regulate blood glucose level. Glucagon and insulin show antagonistic relation.

* Testis

- One pair of testis is present in male individual, outside abdomen (extra-abdominal).
 - Testis is present in a pouch called scrotum or scrotal sac.
 - Testis is extra-abdominal because spermatogenesis (formation of sperm) requires 2-2.5°C less than body temperature.
 - Testis has dual function:
 - (1) primary sex organ
- Spermatogenesis takes place in seminiferous tubules present in testis.

(2) Endocrine gland

- Testis has Leydig/interstitial cells present in intertubular space which produce a group of hormones called androgens (mainly testosterone).



Function of androgen

- (i) Development, maturation and function of epididymis, vas deferens, seminal vesicle, urethra, prostate etc
- (ii) Muscular growth
- (iii) low pitch voice
- (iv) growth of axillary hair, pubic hair and facial hair
- (v) Anabolic effect on protein & carbohydrate metabolism
- (vi) Stimulate erythropoiesis
- (vii) Work on CNS and regulate male sexual behaviour (libido)
- (viii) Aggressiveness
- (ix) Support spermatogenesis.

* Ovary

• one pair, located in abdomen (present in female individual)

• Ovary has dual function:-

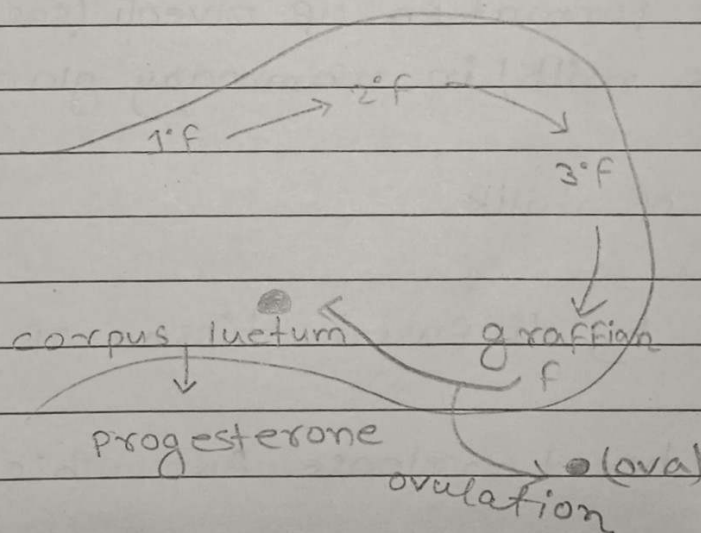
(1) primary sex organ

→ produce 1 ova (female gamete) during each menstrual cycle

(2) Endocrine gland

→ produce hormone:- (i) estrogen (from growing follicle)
(ii) progesterone (from corpus luteum)

Ovary consist of → ovarian follicle (1st F, 2nd F, 3rd F, graffian F)
→ Stromal tissue



* Function of estrogen

- (i) Development, maturation of female secondary sex organ
- (ii) Growth of mammary gland during puberty
- (iii) High pitch voice
- (iv) Regulate female sexual behaviour
- (v) Growth of ovarian follicle

* Function of progesterone

- (i) Support pregnancy
- (ii) Stimulate formation of alveoli (sac like structure that store milk) in mammary gland
- (iii) Secretion of milk

* Hormone by diffused tissue of heart

- Atria of heart release ANF which is hormone
- ANF act as vasodilator. It decrease blood pressure, GFR
- ANF = Atrial Natriuretic Factor

* Hormone by diffused tissue of kidney

- J_W cells of kidney release erythropoietin
- Erythropoietin stimulate erythropoiesis (formation of RBC)

* Hormone by diffused tissue of GIT

(1) Gastrin hormone

- Acts on gastric gland and stimulate secretion of HCl and pepsinogen

(2) Secretin hormone

- Acts on exocrine part of pancreas and stimulate release of H₂O and HCO₃⁻

(3) CCK

- cholecystokinin acts on both pancreas & gall bladder. Stimulate secretion of pancreatic juice and bile juice

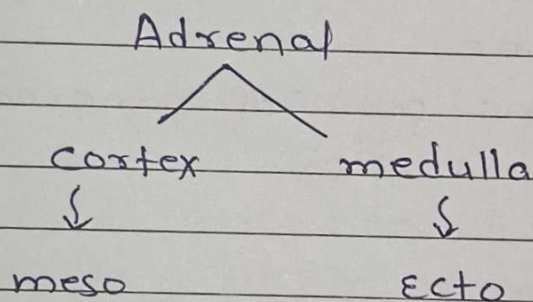
(4) GIP

- Gastric inhibitory peptide inhibit gastric secretion and motility

Note: Several non-endocrine cells release growth factor that helps in growth and repairing of tissue

* Glands and its origin

- | | | |
|------------------|-------------------|---------------------|
| (1) Hypothalamus | } | → Ectodermal |
| (2) pineal | | |
| (3) pituitary | | |
| (4) Thyroid | } | → Endodermal |
| (5) parathyroid | | |
| (6) Thymus | | |
| (7) Pancreas | | |
| (8) Adrenal | → Ecto-mesodermal | |
| (9) Testes | } | Gonads → mesodermal |
| (10) Ovary | | |



* Nature of hormone

(1) Amine nature

- Epinephrin
 - nor-epinephrin
 - melatonin
- } → from Tyrosine
- from ~~ty~~ tryptophan

(2) protein nature

- Hypothalamic hormone
- pituitary hormone
- parathyroid hormone
- Thyrocalcitonin
- Thymosin
- Insulin
- Glucagon

(3) Iodothyronine nature

- T₃ (tri iodo thyronine)
- T₄ (tetra iodo thyronine)

(4) Steroid nature

- Corticoid
- testosterone
- estrogen
- progesterone